Mississippi Agricultural Experiment Station

Agricultural College, Mississippi

BULLETIN No. 140. JULY, 1910.

COTTON DISEASES IN MISSISSIPPI

By R. P. HIBBARD, Ph. D.

CONTENTS.

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1. Introduction.

It is the purpose of this bulletin to present in a concise and convenient form to the cotton growers of this state a statement of our present knowledge concerning the diseases of cotton. This publication is by no means a contribution to scientific literature but a compilation intended as a ready reference and written to supply a demand for it.

2. Disease.

Ordinarily a plant is considered diseasesd when the life of a part or the whole of it is threatened. Strictly speaking the plant is diseased when it is deprived of any of the favorable conditions for growth and development. The development of any plant depends on a series of external factors such as light, proper temperature, kind and proportion of food, plenty of room and a suitable supply of water. When all these external factors combine in the most favorable manner the plant is vigorous and healthy. On the other hand when one or more of these conditions are lacking or over abundant the normal development of the plant is interfered with, to a greater or less extent, and the plant is sickly. After a sickness of this type the plant may recover providing the cause of the trouble is removed. When, however, the sickly condition leads to the death of a part or the whole of the plant, then, according to common custom, we call the plant diseased. This is the interpretation which is taken of this word throughout this paper.

It is therefore apparent that the more the farmer learns of the conditions favorable for his crops so much the more successful will he become in preventing the various diseases. Diseases in plants are contagious or "catching" like certain diseases, namely measles and smallpox in the human race are catching. This is due to the fact that some are more susceptible. They are weaker or less able to resist disease. The same is true among plants. Some plants especially those which have low powers of resistance take disease easily. The previous condition or predisposition of the plant is an important factor to be considered. The presence of the disease agent or parasite is another factor, but, more important than either, is the relation between these two factors. The agent of the disease and the pre-

disposition of the plant may be such that should conditions be right disease would ensue. For example, the Dillon variety of cotton planted in a wilt sick soil has yielded 1½ bales per acre while the Truitt made a very poor yield. In the former case the agent of disease, the wilt fungus, was present but the variety of cotton was such that the disease had no effect on it. The conditions were against any chance for sickness and the result was a good crop. In the latter case the plant was predisposed to the disease, the wilt fungus was present and the result was a poor yield. The agent of disease found in the Truitt variety the conditions favorable for its development. The Truitt variety is therefore considered susceptible while the Dillon is resistant or immune. It must be mentioned here that the factors which contribute to the predisposition of the plant are both external and internal. The first has to do with the plant's surroundings or environment and the latter to internal inherited traits.

3. Symptoms of Disease.

Disease is present in most any field, and at any time, yet it is only at special times that it is apparent enough to attract wide-spread attention. This is a fact in the case of epidemics. When everything is considered, the losses from epidemics are small as compared to those from troubles that are not spectacular in their appearance but nevertheless constantly and unceasingly working injury. It is strange, yet true, that few recognize disease. Every one who makes his living from the soil and what it produces should become familiar with the signs, indications or symptoms of disease. In order to aid those interested, and in the hope of interesting more, in the study of plant diseases and the methods of combatting the same, the following outline as taken from Dr. Heald's article on "Symptoms of Disease" is inserted here:

(1) Discoloration or change of color from the normal.
    (a) Pallor; yellowish or white instead of normal green.
    (b) Colored spots or areas on leaves or stems.
        Whitish or grey: mildews, white rusts, etc.
        Yellow: many leaf spots.
        Red or orange: rusts, leaf spots, etc.
        Brown: many leaf spots.
        Black: black rust, tar spots, etc.
        Variegated: leaf spots, etc.
(2) Shot hole: perforation of leaves.

(3) Wilting: "damping off", wilt, etc.
(4) Necrosis: death of parts, as leaves, twigs, stems, etc.
(5) Reduction in size: dwarfing or atrophy.
(6) Increase in size: hypertrophy.
(7) Replacement of organs by a new structure.
(8) Mumification.
(9) Change of position.
(10) Destruction of organs.
(11) Excrescences and malformations.
Galls: pustules, tumors, corky outgrowths, crown galls, etc.
Cankers: malformations in the bark generally resulting in an open wound.
Punks or conches and other fruits of fleshy fungi.
Witches's brooms.
Rosettes and hairy root.
(12) Exudations.
Slime flux.
Gummosis; especially for stone fruits.
Resinosis; especially for coniferous trees.
(13) Rotting.
Dry rot and soft rot: the "gangrene" of plant tissue.
Root rots: generally woody or fleshy roots.
Stem or trunk: dry rot of trees, rot of modified stems like rhizomes, bulbs, or tubers.
Buds.
Fruits: fleshy fruits of various kinds.

4. Causes.

The cotton plant is subject to many and varied diseases, all of which may be roughly grouped under the following heads: First, fungous; second, bacterial; third, physiological; fourth, mechanical; and, fifth, diseases due to insects. It is not the purpose of this bulletin to discuss the last two topics and these will be passed over without further comment.

5. Losses.

Every year the farmer loses a fraction of his crop. The losses are often as great if not greater than those due to neglect of proper cultivation. In times of epidemics the greater part, if not the whole of his crop is ruined. Certain diseases remain in the soil year after year, and the farmer is at a loss to explain his low yields, and even

should he happen to know the cause, does little or nothing to remedy it. These troubles are usually attributed to season or luck. It is becoming more and more necessary that the farmer know something about the diseases to which his crops are subject. It is important to know the parasites which cause the troubles and to learn something concerning their life histories, in order that correct methods for controlling them may be followed. Every one should study how to prevent disease and how to improve the health of the plants. As much zeal should be displayed in this matter as is shown in taking advantage of all the smaller improvements in cultivation.

At the present time the increasing competition in cotton culture, the decreasing productiveness of many soils, and the introduction of the cotton boll weevil are factors which will aid much in the development of ways and means for the prevention of cotton diseases. In addition it will make the farmer take advantage of every opportunity to increase the quality, quantity and earliness of his crop. All this can be accomplished by a thorough understanding of the necessary conditions for growth and the avoidance of disease.

Throughout the cotton belt the loss by disease varies between twenty-five and thirty millions of dollars. This state suffers a loss ranging from three to five millions yearly and this total is increasing annually. As startling as these figures are they are not nearly so suggestive to the farmer as some personal recollection he may have of local loss. There are many such persons in this state judging from the letters that have been received. These letters are especially numerous when the season is wet and warm for then the conditions are most favorable for fungous troubles.

The amount of injurious fungous diseases differ every season. One season cotton anthracnose may affect only the more sensitive varieties of cotton and the next season will cause a loss of the most resistant forms. All varieties of the cotton plant are not equally susceptible to fungous troubles and this important fact has led to the selection and breeding of varieties which will possess all the qualities desired and at the same time carry the high resistance necessary to combat the fungous pests. Such is the foundation of the most important principle for the prevention of disease in plants, and it is to the farmer's advantage to wage war against plant diseases by selecting pure seed and breeding resistant varieties. That the more progressive farmers are seeing the advantages of such methods is becoming more and more apparent. When more show interest, the time

will quickly come when the crops will be larger and the returns from them greater.

The diseases of cotton are numerous and increasing yearly. As already noted this bulletin will only deal with those caused by fungi, bacteria and unfavorable soil and weather conditions, the latter a class of diseases called physiological.

6. Fungi.

A fungus (plural fungi) belongs to the plant kingdom and is produced from a spore which is similar to the seeds of corn or cotton in this respect that it is the origin or beginning of the mature plant which is later to develop. It differs from the seed by being so small that it cannot be seen except when magnified many times by the aid of a microscope. Again it differs from the seed because it possesses a simple structure. The seed contains the future plant in miniature—the beginnings of the stem, leaf and root. It has therefore a complex structure. The spore is a minute portion of jelly like substance called protoplasm enclosed by a delicate but exceedingly tough membrane or outer coat known as the cell wall. It has therefore a structure of the simplest form.

Fungi are the lower forms of the vegetable kingdom. They vary in size from those that cannot be seen with the naked eye to those of much larger size like the mushrooms, toad stools and shelf fungi. They grow in various places and are found on decaying vegetable and animal matter. Some are pink, some red, some black, in fact almost any color can be found except green. Fungi, therefore, differ from the ordinary green plants since they do not possess this green coloring matter which is called chlorophyll and which by the aid of sunlight has the power of changing the water, the gases of the air, and the mineral salts of the soil into suitable substances for the nourishment of the plant. Fungi being deprived of this method of making food have to subsist on food built up by others, such as animals and green plants. Fungi live as saprophytes or parasites, the former existing on dead and decaying matter, the latter on living matter. As examples of the first we have the moulds found on leather, bread and cheese, and the toadstools developing in the manure piles and damp moist soils. The parasites get their food from the tissues and juices of the living plant or animal, and are represented by such fungi that cause wilts, anthracnose and blights.

Fungi have two structural parts, the mycelium and the spore. The mycelium is the vegetative part and serves the same purpose for

the fungus as the root, stem, and leaf do for the higher plants. This mycelium is composed of fine microscopic threads, more or less branched and twisted to form loose wooly masses like the green mould on leather. Sometimes the mycelium may be compacted to form solid bodies like the toadstools. The mycelium of a parasitic fungus finds some opening on the plant and thus penetrates to the internal tissues and meeting with favorable conditions for growth is soon found developing rapidly. Wounds and breathing pores are suitable openings for the entrance of fungous spores and bacteria. The spore as already noted is the reproductive body and is the beginning of another fungus. Spores develop in great numbers and first germinate on the surface of the plant. In order to germinate they must absorb moisture, a fact that explains the great influence of weather on fungous diseases. In wet weather plenty of water is present and the spore germinates and enters the plant where it there finds suitable conditions for growth and is not further dependent on weather.

Fungi have a shorter period of life as a rule than any of the green plants. Some live but a few days, others until the food supply gives out. They grow rapidly and decay rapidly. Generally speaking there are as many kinds of fungi as there are kinds of higher plants, and so too there are many kinds of spores. They are even as varied as the seeds of garden and field crops. The fungi are classified chiefly on the difference in the appearance of their spores. A certain kind of spore produces the toadstool, another the mold on bread, and still another the puff ball. So the plants of the lower kingdom of which we take so little notice are as varied in form as those we are more intimately acquainted with in every day life. The fungi with which we are concerned in this article are injurious and belong to the class called parasites.

The effects produced by fungi while growing in plants are varied. Any or all parts of the plant may be affected. Some diseases are peculiar to one part of the plant for example, the leaf, stem, root or fruit, and others are found distributed on many parts. The leaf may be covered with spots of various colors or may curl up and drop off. The plant may rot or the fruit become spotted. Plant diseases have received many popular names such as wilts, rots, rusts, smuts, mildews, blight and anthracnose.

The parasitic fungi have been divided into three groups: (1) The external fixed or stationary parasite; (2) the internal fixed parasite; (3) the internal moveable parasite. The first group can be represented by the cobwebby growths found on the stems, leaves, and

fruits. As examples, we have the powdery mildew of the grapes, cucumbers, etc. The second group includes the smuts, rusts, downy mildews, etc., and is much the largest group. The third is characterized by diseases due to bacteria such as black rot of cabbage, blight of apple, pear and quince and the angular leaf spot of cotton.

7. Bacteria.

The forms which we are now to consider are also agents of disease. They are classed among the fungi and known as bacteria. Bacteria are microscopic plants of simple structure and often mentioned as germs, microbes and micro-organisms. They obtain their food, like all other fungi, from organic matter and are unable to manufacture it from inorganic salts. When they exist on living matter, they go by the name of parasites; if on dead or decaying vegetable matter, they are called saprophytes. Bacteria are extremely minute. It would take 25,000 of the ordinary sized rod shaped forms placed end to end to measure an inch. 300,000 billion germs would weigh only an ounce. Bacteria occur in three shapes; namely, rods, spheres and spirals. They increase in number or reproduce themselves by the simple process of splitting in half. It takes about thirty minutes for a germ to reach maturity and reproduce itself. Figuring on this basis one bacterium would in seven hours have one million descendants. In twelve hours there would be about 70 billion and in a few days, if conditions were favorable, there would be enough to fill the air, the oceans, and cover the land. This would happen only under favorable conditions for bacterial growth and such are hardly ever present. There are ever present many natural and artificial checking forces which stop development. Bacteria are influenced as much by their surroundings as we are. Proper conditions must exist or their life terminates. They all need food, the right degree of temperature and a moderate supply of moisture. Germs are found everywhere; in the air we breathe, the food we eat, the water we drink and the soil we tread upon. There are only a few disease producing or pathogenic forms, the great majority being harmless, and quantities of them actually beneficial. Previous to the time when the germ theory of disease was first made public bacteria were considered unimportant. Now, since they are closely related to many infectious diseases, they have been the main factor in the establishment of a new science, bacteriology. Only in recent years have these germs been found to be the cause of a number of most serious plant diseases. They find their entrance into the plant tissues through wounds, breath-

ing pores, and rootlets and are as harmful in their results as the fungi already considered.

8. Physiological Diseases.

The physiological diseases which we are to consider lastly are little known. The causes are often so obscure that little can be found out concerning their nature. As a rule these physiological troubles are due to some disturbance of the natural surroundings or some interruption of the natural functions of the plant. These troubles are often progressive in nature, one stage of disease predisposes the plant to another and it in turn to a third. Different conditions produce different troubles. Cold weather is one common cause of plant troubles of this kind. Injuries usually result from a mild late fall followed by a sudden severe freeze; or from an unusually severe winter; or from mild open winter weather inducing a flow of sap followed by freezing weather; or lastly, an early spring inducing premature blossoming followed by killing frosts. Heat will retard the transpiration of moisture from the plant and produce wilting or tip burn. It will also dry up the soil and in seasons of drought the plant is sickly, wilts, and if not destroyed will ripen prematurely. Water in great abundance is a source of trouble. Excess of stagnant water in the soil prevents the entrance of air to the roots, and induces the formation of poisonous substances and injurious acids which hinder the growth of the plant, if they do not ultimately kill it. A well drained field is one essential to good agriculture. An excess of water on the stem and leaves affords the proper conditions for the germination and spread of fungous diseases. A reduction in the fertility of the soil is also a source of disease. Such soils lack the proper food material. Injury can be done in this way as well as when too much food is present. Fertilizers when used carelessly, burn the foliage, sometimes injure the roots, and often kill the young plants. Sufficient illustrations have been mentioned to show what kind of diseases we designate as physiological. The investigation and solution of these troubles is becoming more and more necessary and remedies for such are as important as those for fungous maladies.

9. Cotton Wilt.

(a) **Occurrence.**—Wilt here described is distinctly different from the wilting caused by drought and the wilting which is the result of a disease of cotton known as root rot. Wilt is widely distributed throughout the State. It has been found in light sandy soil, impoverished soil and in rich black land and on black prairie land. In fact,

it appears that there is no soil suitable for cotton growing where wilt is not met with. When once the soil is infected the disease remains and easily spreads unless efforts are made to prevent it.

Fig. 1. Cotton Wilt (after W. A. Orton, Bull. 333, Bur. Plant Industry, U. S. Dept. Agri.).

Single plants in a field may show the disease. A plant may be only partly wilted while the rest of the plant will be in a vigorous condition. In a row, only here and there, one may see wilted plants. Wilt as above mentioned causes only slight loss, but when definite patches or areas are established and each successive year enlarges these spots we are then confronted with a more serious loss.

Wilt assumes a more serious aspect in the Delta region than in any other part of the state.

The cotton plant is subject to wilt at an early date. When about ten or twelve inches high, it is susceptible and from then on to maturity. Wilt is most abundant in June and July, especially when the rainfall is plentiful in early spring and during the growing season.

(b) **Symptoms.**— The external characteristics are first apparent when the leaves turn yellow at their margins and between the veins. Later the whole leaf becomes yellow and drops off. In extreme cases of wilt nothing but the bare cotton stalks and branches are left. In less severe cases one or two branches may be stripped of leaves while the rest of the plant is apparently unaffected. Wilted plants may partially recover but will always show a stunted or bushy appearance.

It is by means of the internal appearance of the affected cotton stalk that we establish without a doubt the cause of this disease. The

wood in the region of the water conducting vessels that pass up the root and stem is brown. When the stem is cut across with a knife this brown ring is clearly seen and is due to the dense closely woven threads or hyphae of the fungus which has filled up the vessels, shut off the water supply and killed the plant. This brown ring in the

FIG. 2. Cotton Wilt; wilted plant on right, resistant plant on left (after W. A. Orton, Bul. 333, Bur. Plant Industry, U. S. Dept. Agri.)

stem is characteristic of this disease. In addition to the above symptoms the tap root of a wilted plant is shorter, and the lateral roots less abundant.

(c) **Cause.**—This disease is due to a microscopic plant, a fungus which goes by the name of **Neocosmospora Vasinfecta.** It is found in an actively growing state in the soil existing on decaying organic matter. The soil then is its original home or habitat and in this place its existence is that of a saprophyte. But when it enters the root and stem of a cotton plant it changes its nature and becomes parasitic. How does the fungus get within the root or stem? Wounds or abrasions on the roots afford suitable places for the entrance of the exceedingly delicate threads of this fungus. Wounds and abrasions, though suitable centres of infection, are not necessary, for the fungus is able to penetrate even healthy roots. Once within the roots it travels or grows up the sides of the water conducting vessels, finally growing so dense that the cavities are choked up and death results.

(d) **Remedies.**—Cotton wilt cannot be controlled by spraying with fungicides for the cause of the trouble is found within the plant. The soil, which is the natural habitat of the fungus, has been treated in various ways with poisonous substances. None of these solutions have as yet proven efficient. On the other hand they have not only proved impracticable but expensive.

Barn yard manure, though sometimes suggested as a corrective agent, has so far proven of very little practical value. Commercial fertilizers are neither detrimental nor advantageous.

It has been suggested that the soil can be freed from this disease through a system of rotation, yet data have been collected to show that this takes from seven to ten years and the results are not as promising as one would expect. Deprived of cotton as a source of food it still continues living by subsisting on decaying matter and so prolonging its life as a saprophyte for a term of years. Wilt gradually diminishes when the land is put into rotation but is not entirely eradicated for the period of time mentioned above.

The destruction in the fall of all diseased plants lessens in a measure the spread of this disease. At the same time it kills the boll weevil and other injurious insects, and keeps the land in better sanitary condition.

The most efficient method of control lies in the use of resistant varieties that can develop well and reach maturity in spite of the adverse soil conditions—wilt infected soil. These wilt resistant forms have been produced by breeding and selection. Mr. Orton of the Department of Agriculture has produced resistant varieties from both the upland cotton and the Sea Island cotton. Those of the Upland variety are the Dillon and the Dixie. Those of the Sea Island are the Rivers and the Centerville. The farmers that have wilt sick land should by all means plant seed raised from wilt resistant varieties.

10. Anthracnose.

(a) **Occurrence.**—Anthracnose, pink boll, or boll rot is year by year increasing throughout the state. It is present in the Delta region, in the sandy hill region, in the prairie and on the bottom lands. It can be found in all sections of the state where cotton is grown but is more prevalent and exceedingly troublesome in the Delta region, and in the central and northern section of the state. On some farms only a fractional per cent of the crop is lost from this disease, while on others the loss is from 80 to 90 per cent.

The condition of the weather has much to do with the amount of anthracnose. A very dry season hinders the development of the spores and affords a natural means of checking the spread of this disease. On the other hand a wet season creates the most suitable conditions for its development and spread. So little is known about this disease that we are not yet in a position to give a complete discussion.

(b) **Symptoms.**—Anthracnose, pink boll, or boll rot is determined primarily from external characteristics. It is most destructive as a boll disease, yet it also injures the stem, leaf and cotyledons of young seedlings. The first indication of trouble on the boll is shown in the appearance of small reddish brown spots, which grow larger and become depressed in the tissues of the boll. Soon the spores develop and occupy the centers of these spots. Climatic conditions are responsible for the abundance or scarcity of these spores. If the conditions have been favorable, large quantities of spores are produced and the pink color is very apparent, otherwise they are scarce and the diseased areas have a grey cast.

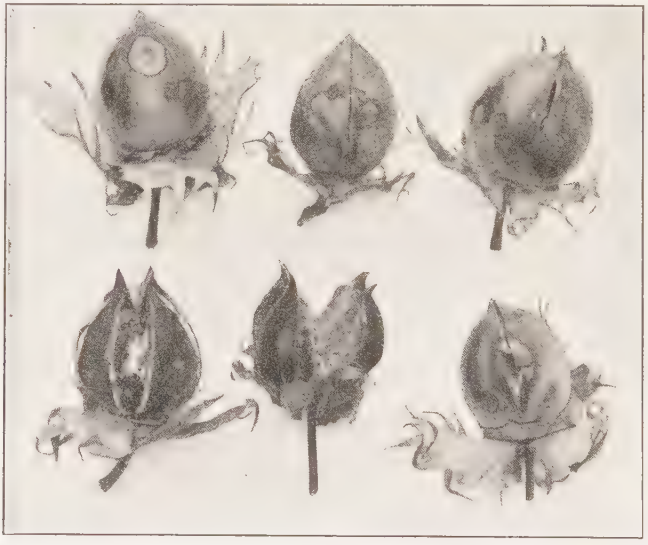

FIG. 3. Anthracnose of Cotton (after R. W. Harned, Bul. 139, Boll Weevil, Miss. Exp. Sta., 1909).

A boll which is badly diseased externally upon opening will disclose rotten and badly discolored lint. The lint in partially diseased bolls is inferior and harbors countless pink spores. The greatest

damage to the bolls is done before they mature. If attacked near the time of maturity, the normal development is interfered with and an imperfect boll partially diseased is the result. From these half opened, dried bolls the lint is hard to gather and oft times is never touched. The loss of cotton in this way is quite a large item.

This fungus also attacks the stems of young plants near the ground often causing death. The cotyledons are also injured by the fungus which is imbedded in its tissues. Greyish or pinkish spots are found on the weaker leaves. The stem may also show these depressed pink or grey areas so constantly met with on the bolls.

(c) **Cause.** -This disease is attributed to a fungus, **Colletotrichum Gossypii.** Its life history has not yet been completely worked out, but much has already been determined through the careful investigations of Professor Barre of Clemson College, South Carolina. Professor DeLoach, when connected with the Georgia Experiment Station, also added much to the investigations on cotton anthracnose. Professor Edgerton of the Louisiana Station has succeeded in finding the perfect stage developing under natural conditions.

The fungus is an active parasite able to penetrate any portion of the cotton plant and cause disease. Professor Barre's investigations show that the fungus winters over in the seeds which, when germinated in the following spring produces the disease in the seedling or young plant. The spores also winter over in the diseased stems, bolls and seed in the field. Ten months appears to be the length of time they can sustain life under adverse conditions. Much has yet to be learned concerning this serious pest which causes considerable loss throughout the state every year.

(d) **Remedies.** –Various remedies have been tried, but our knowledge is yet too incomplete to advise any definite remedy.

Spraying with fungicides has not proven practical, since this would have to be done when bolls were open, thus spoiling the lint. As infection has been traced to the seed the spray would not reach the centre of infection.

Treating the seed with poisonous substances has not proven effective.

By selecting clean seed from bolls unaffected the disease can in a measure be checked.

Professor Barre suggests that a one year's rotation with clean seed ought to eliminate cotton antthracnose. The burning of the stalks in the fall will retard the spread of this fungus pest.

The most attractive and apparently the most successful remedy would be the development of a disease resistant variety.

11. Cotton Rust.

(a) **Occurrence.**—Black rust, yellow leaf blight and mosaic disease are classed under the general term of rust. They are merely different names for the same malady. Rust is common throughout the state and the loss from this disease is considerable. It is present on worn out and light sandy soils or on soils which contain little or no humus. The disease is very likely to appear on wet poorly drained soils. Unfavorable weather conditions also favor the development of rust. Rust develops in spots in the field and appears year after year unless remedies are applied.

From records in this office, though incomplete at present, we learn that most of the rust is located in a narrow strip through the centre of the state from north to south and as far south as Lamar and Marion counties.

(b) **Symptoms.**—This disease affects the leaves. The first indication of trouble is shown in the yellow mottled appearance of the leaf. The yellow portions are farthest away from the source of food supply, the veins. These latter stay green for a longer time. Being deprived to a great extent of the means of sustenance the leaf in a weakened condition becomes a prey to various fungi which ultimately destroy it. The leaves fall off and sometimes the stalk is entirely bare. Such plants do not set a top crop as a rule and therefore the yield is seriously reduced. The lint is often badly damaged being shorter and inferior in quality.

(c) **Cause.**—The disease is due to unfavorable soil and weather conditions. Thrifty and vigorous plants do not suffer until the food supply is withdrawn. The three important factors to which rust is attributed are (1) lack of humus, (2) lack of potash, and (3) lack of drainage. Heavy rains followed by long droughts cause no injury to the cotton plant if the soil is in a condition of proper tilth and fertility. Let these conditions be reversed and serious outbreaks of rust will follow. Diseases of this class are all called physiological, since they are responsible for the constant interruption of the normal development of the plant.

(d) **Remedies.**—The remedy for rust lies in changing the unfavorable soil conditions and in securing conditions that will support a vigorous growth of the plant.

When land has been cropped to cotton for a long term of years it lacks humus or decaying vegetable matter. This kind of soil needs building up and can be done by plowing in a green crop. A crop of cowpeas or beans are especially good. Barnyard manure is beneficial and will do much to prevent rust. Kainit or potash at the rate of 200 pounds per acre will do equally as well as barnyard manure if the latter is not available. Better drainage of wet lands and seepy hillsides will also reduce rust.

12. Red Rust.

Another kind of rust which is often confused with the rust just described is called red rust. The leaves are attacked by a mite which is similar to the red spider. The injury done appears on the leaf and shows itself by a red coloration of a part or the whole of the leaf. In extreme cases this disease causes the complete defoliation of the plant. The trouble is of slight importance. It occurs in new fields as a rule and only in comparatively small patches. Rain checks the spread while dry weather exaggerates the trouble. The insects thrive better in the latter condition. No practical remedy has as yet been found efficient.

13. Damping-off or Sore-Shin.

(a) **Occurrence.** –Sore-shin, damping-off or seedling rot occurs quite widely throughout the state wherever cotton is grown. It does not very often cause serious loss, though many young plants are killed during cold wet unfavorable springs.

(b) **Symptoms.**—The young plants first show signs of weakness in the stem near the surface of the ground. The turgid cells lose the water they contain and become flabby. At this point the stems bend and the plant falls to the ground. Quite often the plants are only partially affected. This is true of the older plants. One side is marred by a canker or ulcerous depression. Unless these diseased spots interfere seriously with the normal functions of the plant, the latter will partially recover but will never be normal.

(c) **Cause.**—The sterile fungus, rhizoctonia, is usually considered the cause of this trouble. Its natural habitat is the soil.

The disease is sometimes due to the anthracnose fungus or other parasites. Such damping off disease must be clearly distinguished from wilting due to dry soil or dry air. If warm favorable weather prevails, the cotton seedling may outgrow the disease.

(d) **Remedies.**—As the sterile fungus prefers acid soils, and alkaline soils are fatal to its growth it would follow that the addition of lime to the soil would be exceedingly beneficial.

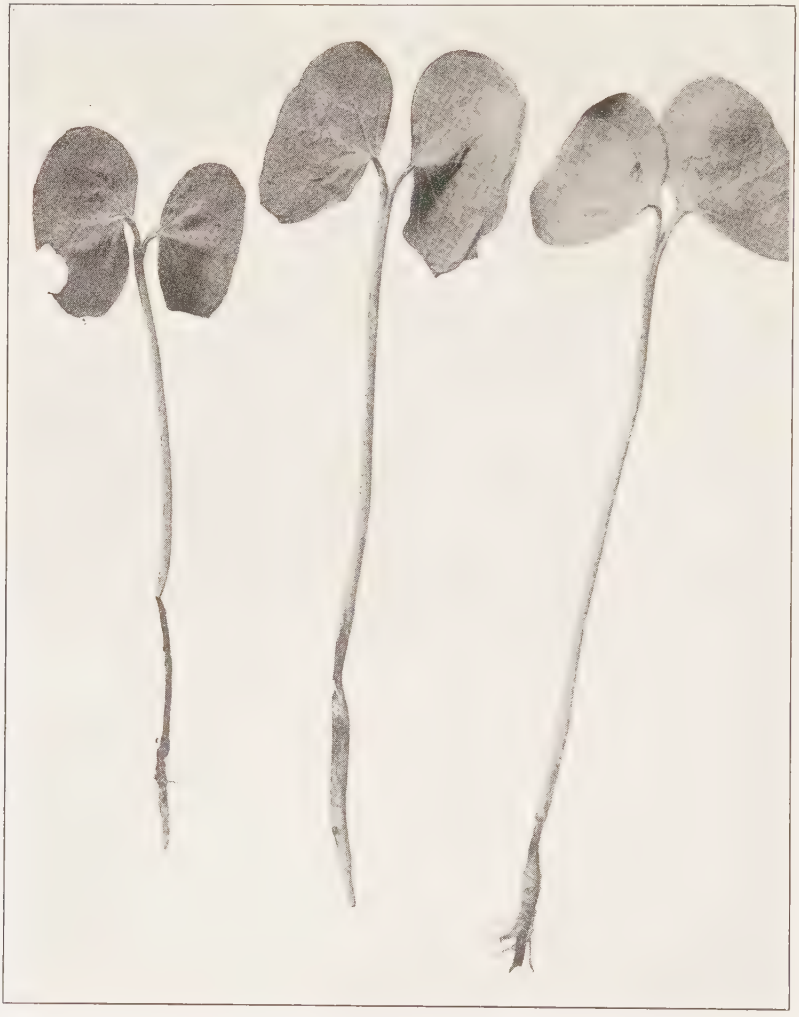

FIG. 4. Sore-Shin or Damping-Off of Cotton (after F. D. Heald).

14. Bacterial Blight.

(a) **Occurrence.**—This disease is known to attack the stem, boll and leaf. On the stem the trouble goes by the name of black arm;

on the boll, boll-spot; and on the leaf, angular leaf spot. All three diseases are due to one and the same cause, a bacterium or microbe. This blight is probably found in every cotton field during the summer months but only after careful search would one be able to see it. The trouble is not yet of economic importance.

(b) **Symptoms.**—The first appearance of the disease is on the under surface of the leaf. Here one finds green colored, water-soaked, angular areas of varying sizes. Later these spots appear on the upper surface of the leaf, the fungus having grown through the leaf. These spots turn purple and finally become brown. These diseased areas seem to be scattered about the surface of the leaf without any definite arrangement but on closer examination they are found to surround the breathing pores or stomata. The method of infection then is chiefly through these breathing pores.

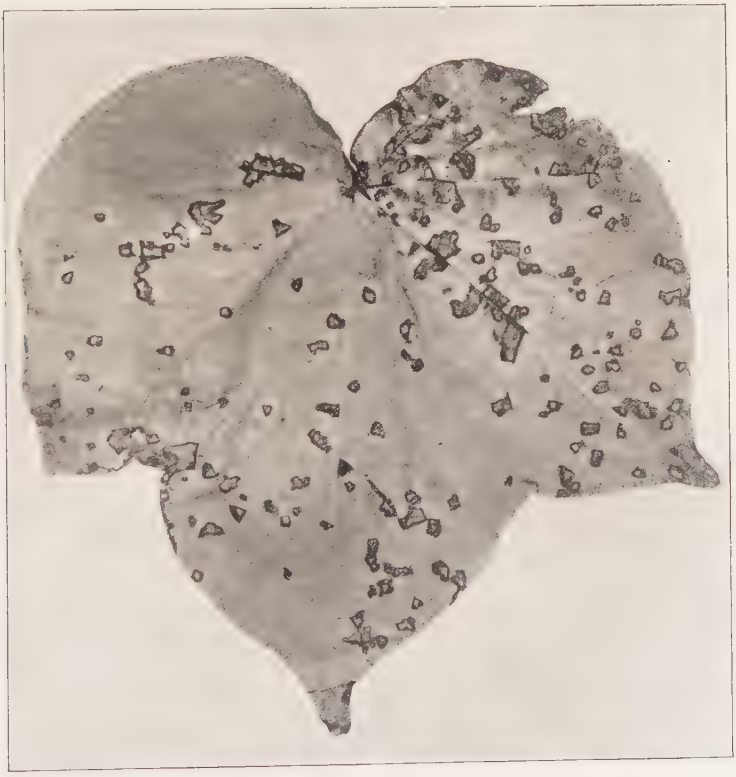

Fig. 5. Angular Leaf Spot of Cotton (after Dr. E. F. Smith).

The symptoms that appear on the bolls are very similar to those on the leaf. The injury on the stem appears in the form of a canker. or ulcer which saps the vitality of the plant. The shedding of bolls is sometimes due to the injury from this bacterium. The stems, bolls and pedicels, like leaves, may weaken and lose vitality. This affords suitable conditions for the invasion of parasitic fungi and bacteria, chief among which is the anthracnose fungus.

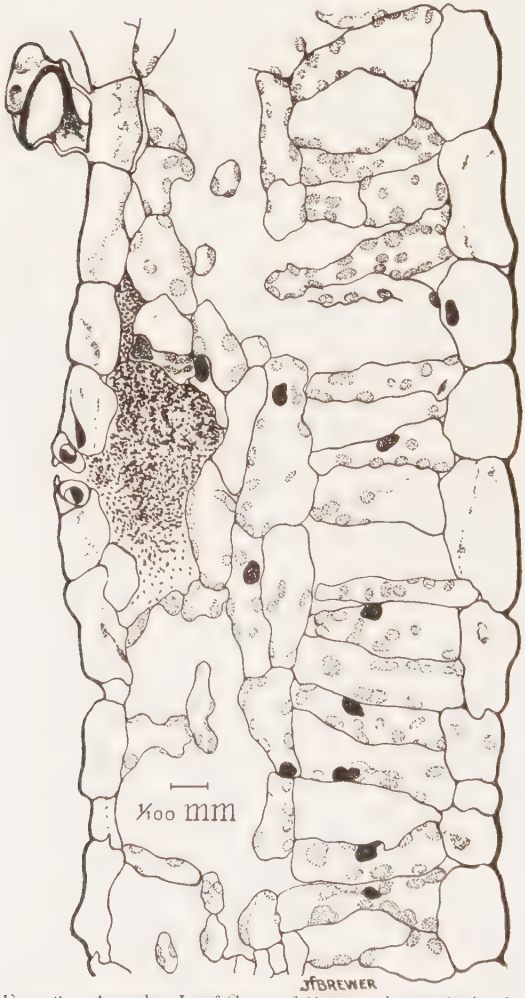

FIG. 6. Angular Leaf Spot of Cotton; bacteria in the tissues of the leaf (after Dr. E. F. Smith).

(c) **Cause.**—In the angular spots on the leaves and the water soaked areas of the bolls countless numbers of microbes are to be found. These were isolated by Dr. Erwin F. Smith of the Department of Agriculture to which he gave the name of **bacterium malvacearum.** The final destruction of the plant is due often to the presence of the anthracnose fungus and certain decay bacteria.

(d) **Remedies.**— There has been little necessity for a remedy and therefore no efficient method has been worked out. The disease usually appears during the time when the cotton is most vigorous and succulent and may be partially checked therefore by so treating the soil that less succulent plants are produced. This can be done by reducing the supply of nitrogen and increasing the potash content of the soil. It has been suggested that the infection is carried in the seed. The trouble could

then be lessened or checked by the selection of clean, healthy seeds from well matured healthy bolls.

15. Shedding of Bolls.

(a) **Occurrence.**—Squares, forms and young cotton bolls often fall for other causes than that due to the injury by insects. Not all of the shedding can be attributed to the boll worm or weevil. In many instances no fungus or insect can be found on or in the affected parts. Such shedding is simply an outward manifestation of improper or faulty nutrition and assimilation. The disease is a physiological one. Climatic conditions have much to do with the presence or absence of this trouble. It is quite common in either very dry or very wet weather. It is also present during the change from one extreme to the opposite. If the plants are crowded and the growth rank, sufficient food is not available to supply all fruit forms especially those furtherest from the course of supply, consequently many squares fall.

Some varieties of cotton seem to be more susceptible than others. Certain soil conditions have a detrimental influence and aggravate this trouble. Even the character of the fertilizer is said to show a marked effect on shedding. During some seasons the loss by this disease is considerable. Under normal conditions there is also a loss which, however, does not reach an alarming stage.

(b) **Symptoms.**—The symptoms are easily recognized. The parts affected change in color from a deep green to a pale green and finally become yellow. In the majority of cases the forms drop off, yet it is not uncommon to find some attached to the parent plant by a few strands of the peduncle or stalk.

(c) **Cause.**—This disease is a physiological one and cannot be attributed to any one cause. It is rather the result of a series of causes which are constantly changing. Such causes are the unfavorable conditions of climate and soil.

(d) **Remedies.**—Physiological diseases have as yet received little attention at the hands of plant pathologists and for that reason it is difficult to give any reliable remedy. We have no control over climatic conditions and therefore the hope of a suitable remedy lies in the direction of a thorough study of soil conditions. A system of soil preparation, culture and fertilization with a view to affording the best conditions for the development of the plant should do much towards checking this malady.

16. Root-Knot, Root-galls, Root Nematodes.

(a) **Occurrence.**—Only a few cases of root-knot of cotton in this state have been brought to my attention, yet I am loath to believe that it is not quite common, especially on thin sandy soil and worn out lands. Cotton growers are probably more ignorant of the presence of this disease in their fields than any other. This is likely the true explanation of the lack of satisfactory information on the distribution of this trouble throughout the state. Mr. Orton, of the Department of Agriculture, has found that root-knot of cotton is often associated with wilt. Root-knot so weakens the root system that it affords easy or favorable conditions for the entrance of the wilt fungus. Many weeds and cultivated plants are subject to this trouble. One of our best soil renovaters, the cowpea, is very susceptible. It is bad economy to follow diseased cowpeas with cotton.

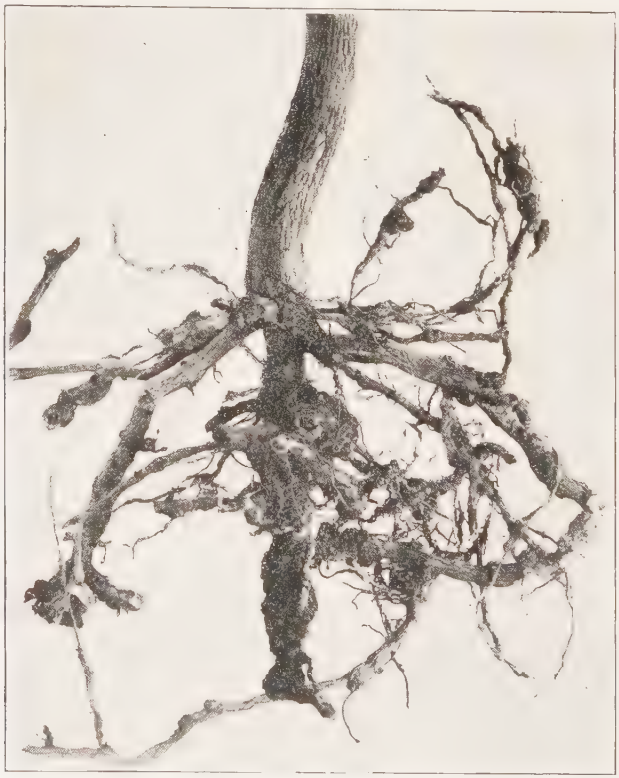

FIG. 7. Root-Knot on Cotton Plant (after W. A. Orton, Bull. 333, Bur. Plant Industry, U. S. Dept. Agri.)

(b) **Symptoms.**—Root-knot is a disease that attacks the roots or underground parts of the cotton plants. All cotton plants suffering from root knot are dwarfed. When the roots are badly diseased, the plant suffers a lack of food and water, wilts and finally dies. A plant may not show any striking symptoms but on examining the roots the cause of the disease can be easily determined. They are covered with warts, galls or excrescences of various sizes and shapes, and sometimes are as large as an inch in diameter. When the affected roots begin to die they send out new roots so that before long the root system becomes bushy and tangled.

(c) **Cause.**—This root affections is due to a microscopic worm about 1-20 to 1-60 of an inch long. It burrows into the root, thus setting up an irritation which later produces these wart like excrescences or knots. If these knots are numerous the nutrition of the plant is interfered with. It becomes enfeebled and finally dies.

(d) **Remedies.**—No treatment of diseased roots with poisons, is practicable since the amount necessary to kill the worm would also seriously injure the root. Carbon bisulphide, arsenic and kerosene emulsions have been tried without success.

Alkaline fertilizers such as kainit, potash, and lime have been mentioned as good checking agents.

Allowing the land to go fallow for two seasons has resulted in almost ridding the soil of the worm. This method is expensive and unnecessary since there are crops that can be grown on land containing the root-knot organism without receiving any injury. Wheat, oats and rye are examples of such crops.

Clean cultivation which would rid the soil of infected weeds and diseased crops would be of great value in retarding the spread.

The best means of control rest in a proper system of rotation. using crops that are not susceptible, and in this way starving out the nematodes.

17. Root Rot.

(a) **Occurrence.**—No root rot has been reported to the department as coming from this state. It is found in Texas where it causes a great deal of damage. It has not yet been found east of Texas (1906) but it is likely to spread in this direction. It is a soil fungus and, like its neighbor, the wilt fungus, is liable under favorable conditions to spread rapidly in the ground after it has once established itself. All types of soil are more or less subject to it. The lime soils of Texas, as

well as the black waxy lands which hold moisture so tenaciously have proven the most suitable soils for the development of this trouble.

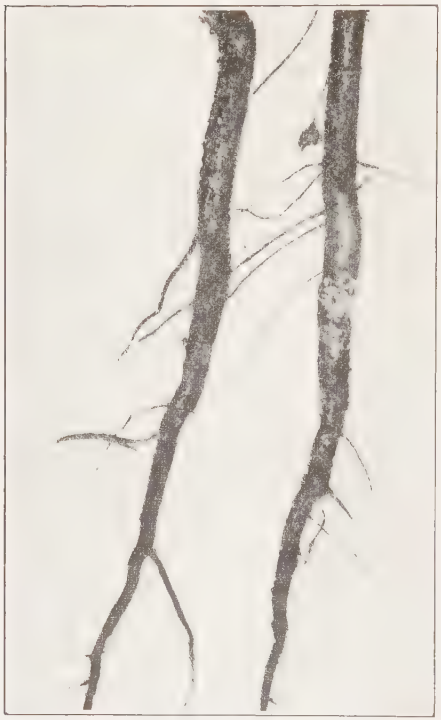

FIG. 8. Ozonium Omnivorum on Roots of Cotton (after B. M. Duggar.)

(b) **Symptoms.**—The first indication is a sudden wilting followed by the death of the plant in most cases. The disease usually appears about the latter part of June or the first of July though it can be found at an earlier date and even when the plant is more mature. On pulling up the plant and examining the roots closely a further indication of disease can be noted. The diseased roots are covered with dirty yellowish filaments of the fungus which causes the trouble. Sometimes numerous scars are visible on the roots. The smaller roots are dead and dried up.

(c) **Cause.**—This disease is attributed to the work of a parasitic fungus which lives in the ground and rapidly spreads throughout the soil. It can enter the roots, through wounds but is perfectly able to penetrate healthy roots. Its strands or mycelia plug up the water conducting vessels and cut off the water and food supply. This fungus remains in the root and unlike the wilt fungus does not extend into the stem.

(d) **Remedies.**—Soil treatment with poisonous substances or fungicides is not an effective means of control. Attempts to breed a resistant variety have failed.

Deep plowing, together with a proper system of rotation seems at present to be the only adequate means of checking this disease Mr. Shear of the Department of Agriculture, advises fall plowing at a

depth of 7 to 9 inches. In addition to this he advises a two or three year rotation with grasses or grains. The deep plowing aerates the soil to quite a depth and offers unfavorable conditions for the development of the fungus which thrives better in a compact soil that lacks air. That this work may be properly done, the cotton mule and ordinary plow will have to be replaced by heavy animals and 12 to 14 inch plows.

18. Areolate Mildew.

This disease and the one following will be mentioned briefly since they are of slight economic value.

Areolate mildew sometimes called frosty blight from the white snowy appearance of the under surface of the leaf occurs in the late summer and fall, and is found on the rank luxuriant plants growing in moist places. The fungus, **Ramularia areola,** which is the cause of this trouble, produces a partial defoliation of the plant, but as this takes place late in the season there is no appreciable interruption of the normal functions of the plant. This trouble has not proven serious enough as yet to warrant any investigations concerning methods of control.

19. Cotton Leaf Blight.

This disease is very common on cotton. It is found on the less vigorous or old leaves. It is likely to attack all the leaves of weak plants if the soil is wet and the climatic conditions favorable for the development of the fungus. This trouble affects the leaves by producing spots upon them. These spots are red at first, grow larger centrifugally and later turn brown. Sometimes the centers of these spots are white. This is the case when the spores are abundant. In the last stages of disease the leaves are ragged and full of holes. The fungus **Cecrospora Gossypina,** is the direct cause of this leaf blight. The strand or filaments are found within the plant while the fruiting bodies or spores are produced on the surface.

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